

Rejections Under §§ 102(e) and 103(a) Based on Hayashi and on Kato

The Examiner's arguments in support of his rejections based on Hayashi and on Kato are essentially identical to those in previous Office Actions and will only be summarized here for convenience. Briefly, the Examiner contends that Hayashi teaches all of the attributes of the claimed positive electrode active material either explicitly (such as elemental composition and mean particle size) or inherently. Specifically, the Examiner takes the position that since the positive electrode active materials disclosed by Hayashi and the present application have similar chemistry and manufacturing procedures, properties of the Hayashi material which are not disclosed, such as BET surface area, particle size distribution and full width at half maximum of a particular crystallographic orientation, are inherent. Additionally, the Examiner contends that since Hayashi has identified pH and mixing of the solution as processing variables in the fabrication of a positive electrode active material, it would have been obvious to one having ordinary skill in the art at the time of the invention to adjust the pH values or the degree of mixing and stirring of the solution to yield nickel hydroxide or nickel oxyhydroxide powders of desired circularity and distribution of circularity.

Similarly, the Examiner maintains that Kato also teaches or suggests all of the claimed elements, including a positive electrode material for an alkaline storage battery comprising nickel hydroxide particles and a higher cobalt oxide, in which the NiOH particles have the claimed particle size and surface area. The Examiner takes the position that other properties of the material, such as particle size distribution and full width at half maximum of a particular crystallographic orientation, are inherent, given that the positive electrode active materials disclosed by Kato and the present application have similar chemistry and manufacturing procedures. The Examiner contends that since Kato has identified pH and temperature of the solution as critical processing variables in the fabrication of a positive electrode active material, it would have been obvious to one having ordinary skill in the art at the time of the invention to adjust the pH and temperature of the solution to yield nickel hydroxide or nickel oxyhydroxide powders of desired circularity and distribution of circularity.

In response to Applicants' previous argument that Kato and Hayashi do not teach or suggest that the particle circularity of the active material is greater than 0.95 and less than 1 as determined by a particle image analysis with a flat sheath flow utilizing hydrodynamics, the Examiner takes the position that properties of the nickel hydroxide powder, such as BET surface

area, particle size distribution and full width at half maximum of a particular crystallographic orientation, are inherent, given that the positive electrode active materials disclosed by Hayashi, Kato and the present application have the same chemistry and manufacturing procedures. The Examiner contends that the measurement of circularity of the particles is not distinguished by how the measurements are made or where the measurements are performed. The Examiner concludes that the fact that the circularity in the instant disclosure is determined by a particle image analysis with a flat sheath flow utilizing hydrodynamics would not provide patentable distinction over the prior art.

For all of these reasons, the Examiner maintains that both Kato and Hayashi anticipate or render obvious all of the pending claims. Applicants again traverse these rejections for the reasons set forth previously and for the additional reasons which follow.

As previously explained on the record, the present invention relates to a positive electrode active material for an alkaline storage battery containing a nickel hydroxide powder and/or a nickel oxyhydroxide powder, in which the positive electrode active material exhibits particular physical properties, and a method of making a positive electrode using such a positive electrode active material. The positive electrode active material has a mean particle circularity of greater than 0.95 to less than 1, as determined by a particle image analysis with a flat sheath flow utilizing hydrodynamics, and the number of particles having a circularity of not larger than 0.85 accounts for not more than 5% of the total number of particles within the positive electrode active material. When preparing the active materials according to the invention, the pH, stirring and temperatures of the raw material solutions are adjusted and carefully controlled. These parameters are essential for producing nickel hydroxide which exhibits the claimed properties.

The Examiner asserts that Hayashi has identified pH and the mixing (stirring) degree of the solution as processing variables in the production of the positive electrode active material. Applicants respectfully traverse the Examiner's understanding of Hayashi and his conclusion that the chemistry and manufacturing procedures are the same as the present invention.

In col. 3, lines 27-41, Hayashi describes the synthesis of nickel hydroxide via reaction of an aqueous nickel sulfate solution with an alkali such as sodium hydroxide. Once the nickel hydroxide has been formed, the sulfate ion in the nickel hydroxide is removed by treatment with an aqueous alkaline solution such as sodium hydroxide. Hayashi teaches that "the degree or extent of removal of the sulfate ion can be controlled by adjusting the pH of the aqueous alkaline

solution used, and the duration and times of alkali treatment.” Hayashi does not teach or suggest that the pH of the reaction solution used to produce nickel hydroxide is adjusted, rather, the pH adjustment of Hayashi occurs after the nickel hydroxide has been formed.

Further, in Example 1, Hayashi teaches that, “nickel hydroxide used in this example was produced by mixing and stirring an aqueous nickel sulfate solution and an aqueous sodium hydroxide solution thereby depositing nickel hydroxide” (col. 4, lines 33-36). In this example, nickel hydroxide materials were treated with aqueous sodium hydroxide solutions having different pH values to remove anions such as sulfate. However, there is no teaching or suggestion that the mixing is a processing variable which was varied or optimized in any way, merely a teaching that the nickel sulfate and sodium hydroxide solutions were mixed and stirred to form nickel hydroxide.

The Examiner also argues that Kato has identified pH and temperature of the solution as critical processing variables in the production of a positive electrode active material, referring to col. 2, lines 15-45. However, this section of Kato actually teaches that the pH and temperature of the solution are important in the synthesis of cobalt hydroxide serving as a conductive agent. This description is not related to the production of nickel hydroxide.

In Example 1, Kato teaches that, “an aqueous solution containing nickel sulfate as a main component and cobalt sulfate and zinc sulfate, which are contained in an amount that a molar ratio of cobalt and zinc to nickel is 0.02 and 0.05, respectively, was prepared. To this aqueous solution, an aqueous sodium hydroxide solution was slowly added dropwise while adjusting the pH of the solution with an aqueous ammonia, thereby to deposit spherical solid solution nickel hydroxide particles (col. 11, lines 49-63).” However, Kato does not disclose any detailed reaction conditions in the production method of nickel hydroxide, such as the temperature or appropriate pH, nor suggest that such parameters are critical to the production method, despite the Examiner’s contention to the contrary.

For these reasons, Applicants respectfully submit that Hayashi and Kato have not identified pH, degree of mixing/stirring, or temperature as critical process parameters in the production of nickel hydroxide.

Both Hayashi and Kato are silent as to the mean particle circularity of nickel hydroxide. However, it is virtually impossible to obtain the nickel hydroxide of the present invention unless attention is focused on the intended particle circularity or circularity distribution, and reaction

conditions are adjusted to those which will yield the desired properties. Since these conditions are not taught by Hayashi or Kato to be processing parameters, and since their specific values or conditions are not disclosed by Hayashi or Kato, it is unreasonable to assume that the materials of Hayashi or Kato would inherently exhibit the claimed properties.

The Examiner contends that Hayashi and Kato might have produced the same active material as that of the present application, since Applicants have not clearly shown the differences between the production conditions of Hayashi and Kato and those of the present invention. However, Applicants did not repeatedly conduct experiments using the same raw materials and devices used by Hayashi or Kato or at the same season. Even a difference in the size of a reaction vessel causes changes in parameters which are necessary to obtain a desired particle circularity, such as the degree of mixing, the temperature inside the reaction vessel, the pH, etc. Because of the variability of such parameters, it is nearly impossible to specify the differences between the conventional production conditions and the production conditions of the present invention.

One having ordinary skill in the art would typically consider it to be sufficient to achieve only a degree of stirring capable of fully dispersing raw materials. It is also known that when using a conventional stirrer and stirring blades, those of ordinary skill in the art usually perform stirring that is tens or hundreds of times greater than the amount of stirring which is capable or sufficient to fully disperse raw materials. When performing such powerful stirring, one skilled in the art would never worry about small fluctuations in stirring degree. In other words, it has conventionally been considered sufficient and necessary to perform a certain level of stirring. Therefore, given the lack of a teaching to the contrary in Hayashi and Kato, there would have been no motivation based on Hayashi or Kato to increase the degree of stirring and to maintain such a high degree of stirring for a given period of time, as described in the Examples of the present application.

In order to obtain the high mean particle circularity and sharp circularity distribution according to the present invention, it is necessary to appropriately adjust various parameters, such as the temperature of the reaction solution, the shape of the stirring blades relative to the reaction vessel, and the stirring speed. These adjustments can be readily performed by one skilled in the art once a "target value" has been established.

For example, when using a newly assembled device, it is necessary to perform test productions of nickel hydroxide in order to appropriately adjust various conditions necessary to achieve “targeted” mean particle circularity and circularity distribution. Similar adjustments of production conditions are necessary in producing any products. However, it is impossible to adjust the production conditions of nickel hydroxide if “targeted” mean particle circularity and circularity distribution are not set. The adjustments which are made are different than those performed when pursuing the manufacturing efficiency of nickel hydroxide, when conditions are adjusted to shorten production time and improve yields. Thus, variation of production conditions is dependent upon the result which is targeted or desired.

As recited in claim 1, the particle circularity and circularity distribution of the active material of the present invention is characterized in that: (a) the mean particle circularity is greater than 0.95; and (b) the number of particles having a circularity of 0.85 or less accounts for not more than 5% of the total number. While feature (a) is very unique, feature (b) is more unique and produces prominent effects, as can be seen from Table 1 and Fig. 5 of the application.

For example, when Example 1 (mean particle circularity 0.95, number of particles having a circularity of 0.85 or less of 10%) is compared with Example 2 (mean particle circularity 0.96, number of particles having a circularity of 0.85 or less is less than 5%), the battery of Example 2 exhibits a 48mAh increase in battery capacity and a 3% improvement in capacity retention rate. These differences in characteristics are attributed to the fact that the mean particle circularity is greater than 0.95.

When the mean particle circularity is 0.95 or less, the ratio of particles having a small circularity is larger than that of Example 2. Thus, when the mean particle circularity is 0.95 or less, reducing the number of particles having a circularity of 0.85 or less has no effect on the characteristics. It is only when (a) the mean particle circularity is increased to greater than 0.95 and (b) the number of particles having a circularity of 0.85 or less is limited, that the improvements in characteristics described above can be achieved in the already mature field of alkaline storage batteries. In other words, the combination of features (a) and (b) produces the excellent effects of the present invention. There is no basis for the Examiner’s assumption that Hayashi or Kato discloses nickel hydroxide having both features (a) and (b).

In the industrial production of batteries, a battery design should not be based on an active material having very low productivity, since a highly practical battery design is necessary for

mass production of batteries. In other words, battery design must be based on an active material with modest characteristics which has good productivity. It appears that the nickel hydroxides synthesized according to Hayashi and Kato do not have the same mean particle circularity and circularity distribution as those of the present invention, and thus it is not possible for conventional batteries to have the same performance as that of the present invention (See Examples 2 and 3).

If battery design is based on an active material having very low productivity, the capacity balance between the positive and negative electrodes becomes poor and most of the resultant batteries become defective. As shown in Fig. 5 of the present application, the positive electrodes prepared according to Examples 1-3 and Comparative Example 1 were evaluated to determine the filled amount of active material. The graphs show the distributions of the filled amount of active material for each positive electrode, which were each converted to a capacity. It can be seen that the order of variation of filled amount was $3 < 2 < 1 < \text{Comp. 1}$. Thus, each of the inventive positive electrodes was more uniform in theoretical capacity than the comparative electrode.

As further seen in Fig. 5, the filled amount distribution of active material in Comparative Example 1 exhibits a peak at 2000 mAh (d). On the other hand, in Examples 2 to 3, there is a peak at 2050 mAh, (b) and (c). There are almost no batteries which exhibit a capacity of 2050 mAh, and thus if a battery is designed to be based on 2050 mAh as in Comparative Example 1, most of the resultant batteries will become defective.

Finally, Applicants maintain that since Hayashi and Kato do not recognize the parameters which needed optimization, that is, particle circularity and circularity distribution, nor the profound effects such parameters would have on the resulting battery properties, one skilled in the art would not have been motivated to adjust the reaction conditions of the prior art in order to arrive at the claimed positive electrode active material. Rather, such an assumption which is made by the Examiner is merely hindsight from the present invention.

Therefore, since Kato and Hayashi do not teach or suggest controlling the raw material solution at a constant temperature, or that the particle circularity of the active material is not smaller than 0.95, or that the number of particles having a circularity of not larger than 0.85 accounts for not more than 5% of the number of total particles, one skilled in the art would not arrive at the present invention based on the prior art. Further, the significant effects observed in

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the batteries and active materials according to the invention relative to those in the prior art would overcome any *prima facie* case of obviousness, were one to be established. These effects and unexpected results have been previously described on the record and will not be repeated in the interest of space.

For all of these reasons, Applicants respectfully submit that the pending claims are not anticipated by or rendered obvious over Hayashi or Kato, and reconsideration and withdrawal of the § 102(e) and § 103(a) rejections are respectfully requested.

In view of the above Remarks, Applicants respectfully submit that the pending claims are patentably distinct over the prior art of record and in condition for allowance. A Notice of Allowance is respectfully requested.

Respectfully submitted,

FUTOSHI TANIGAWA et al.

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By:

SANDRA M. KATZ

Registration No. 51,864

AKIN GUMP STRAUSS HAUER & FELD LLP

One Commerce Square

2005 Market Street, Suite 2200

Philadelphia, PA 19103-7013

Telephone: 215-965-1200

Direct Dial: 215-965-1344

Facsimile: 215-965-1210

E-Mail: skatz@akingump.com

SMK:rc